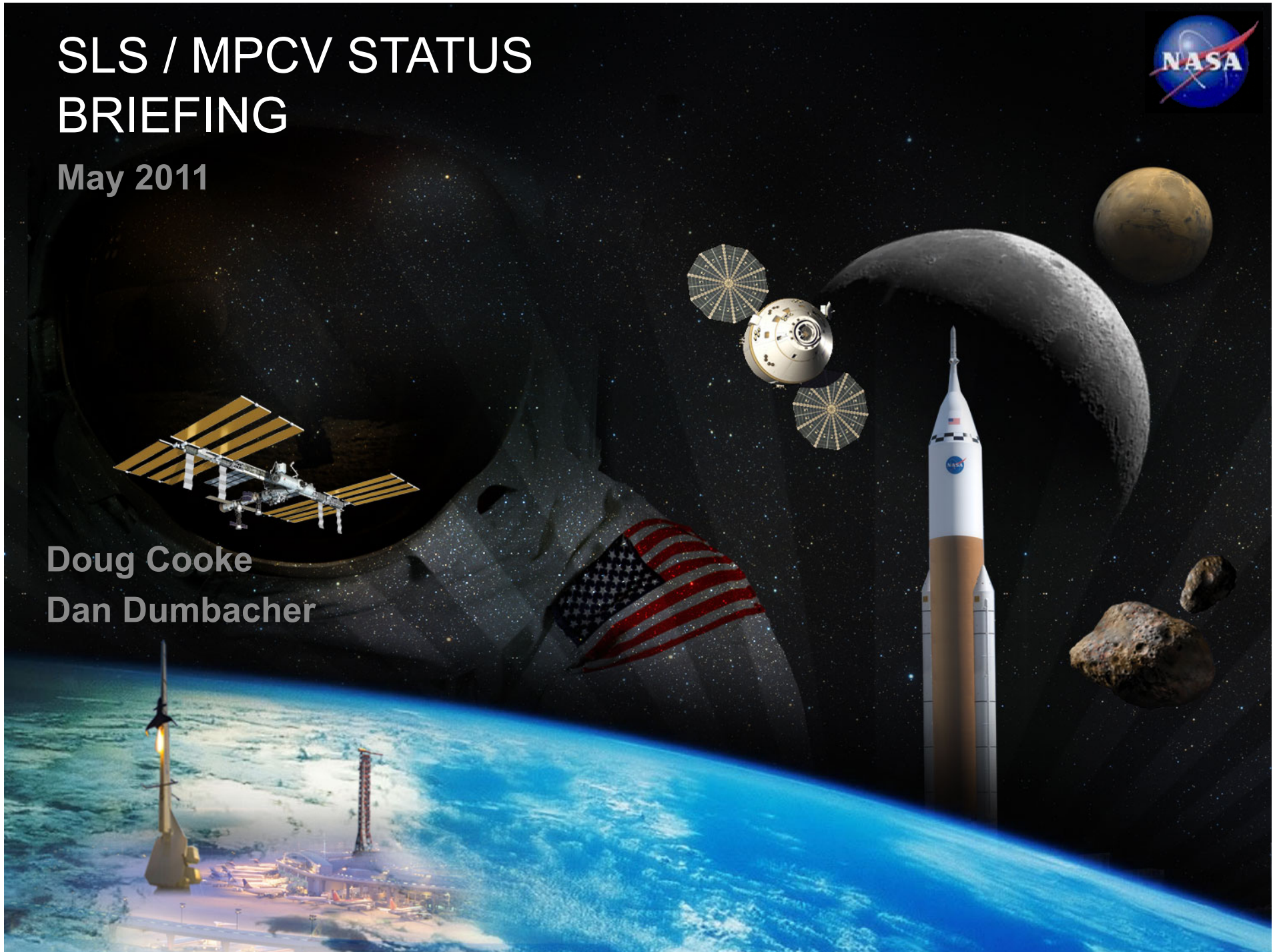




SLS / MPCV STATUS BRIEFING

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Background



- **NASA is developing plans for exploration systems that are affordable, sustainable, and realistic**
 - To keep Congress informed, NASA is providing this update on our progress and plans
- **NASA has selected a Reference Vehicle Design for both the SLS and MPCV**
 - Consistent with direction in the NASA Authorization Act of 2010
 - Provides a baseline from which to start developing schedule, costs and requirements, as well as acquisition plans
- **NASA continues to examine alternative designs to validate and/or challenge those concepts**
 - Due diligence to ensure final vehicle choices will be the best value for the taxpayer with respect to cost, risk, schedule, performance, and impacts to critical NASA and industrial skills and capabilities
- **Before plans for these critical capabilities for future human exploration are finalized, NASA is exploring key details of designs and preparing an integrated plan through a SLS/MPCV Integrated Analysis Process**

Completing Congressional Report for SLS and MPCV



Successful completion of the SLS/MPCV Integrated Analysis Process will enable NASA to complete the Congressional Report by late Spring/early Summer

- **Key updates will include:**

- The basic framework for a capability driven architecture and concept of operations that provides the strategic context for exploration of multiple destinations
- Analysis of the cost and benefits of the Reference Vehicle Designs for the SLS and MPCV as well as alternate vehicle designs
- Analysis of the current Ares, Shuttle and Orion contracts for their applicability to the future development program
- Analysis of potential acquisition approaches

Topics for Discussion Today



- **Overall Strategy to Achieve Integrated SLS/MPCV Plan**
- **SLS and MPCV Alternatives**
- **SLS/MPCV Integrated Analysis Process**
- **Next Steps**



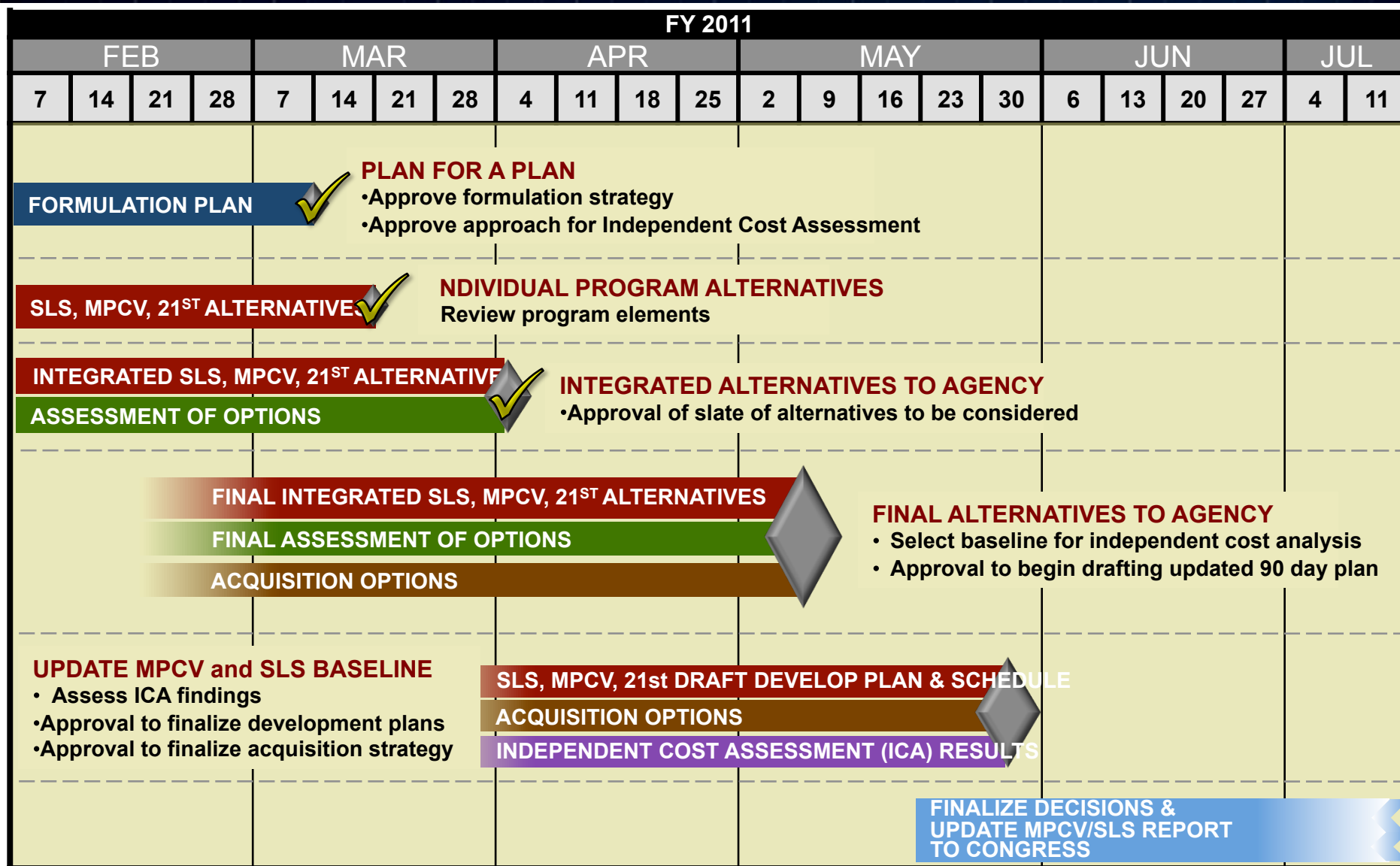
Overall Strategy to Achieve Integrated SLS/MPCV Plan

Overall Strategy to Achieve Integrated SLS/MPCV Plan



- **Successful development of new Human Exploration Systems requires careful planning, analysis and integration**
 - SLS, MPCV and supporting elements are coupled, so planning requires cycles of consideration of individual elements, followed by integrated planning in order to achieve solutions that are technically viable and affordable
- **Element planning activities:**
 - Complete SLS architecture trades, including inputs from industry through NASA study contracts
 - Validate MPCV requirements
 - Develop initial plans for Ground Operations and other supporting activities
 - Develop element acquisition strategy and assess procurement options
- **Integrated planning activities:**
 - Combine single element inputs into a set of integrated options that align SLS and MPCV to deliver an integrated capability
 - Conduct an independent cost assessment to improve confidence in budget requirements
 - Validate integrated acquisition strategy and procurement options
- **Results will comprise key components of updated Congressional Report on NASA's Space Launch System and Multi-Purpose Crew Vehicle**

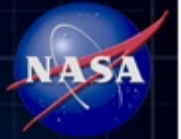
Milestones Leading to an Integrated SLS/MPCV Plan



Integrated Independent Cost Assessment



- **Why have an ICA now?**
 - Integrated, early ICA will be an important “sanity check” of NASA-generated integrated cost and schedule estimate
 - Since key goal is affordability, ICA is part of NASA’s due diligence
 - The ICA will *inform* (not establish) the Program Budgets
 - Integrated, early ICA will reflect the maturity of the program concepts
 - SLS and MPCV are at very different points of maturity along the program life cycle
 - Acknowledge that Program content in early planning (especially for SLS) may not fully capture and reflect all potential content in cost estimate (e.g., ground systems, software, etc.)
 - Confidence level of the ICA will reflect this lack of definition – the integrated picture of SLS and MPCV is not at the point where a Joint Confidence Level (JCL) assessment or even a risk-based cost assessment can be accomplished
- **Further independent technical, schedule and cost analyses will be performed as part of NASA’s standard processes for reviewing and approving Programs as they move through key decision points**



SLS and MPCV Alternatives

SLS and MPCV Element Alternatives Overview



- **NASA's goal is to develop an exploration architecture consistent with direction in the NASA Authorization Act of 2010 which fits within available budgets and is affordable over the long term**
- **The Element Alternative Studies will:**
 - Determine if utilizing heritage systems will help expedite the development process and flight dates compared to alternatives
 - Determine if one of the alternatives would provide combined development and life cycle costs that are dramatically reduced compared with the Reference Vehicle Design
 - Incorporate affordable approaches into the implementation plans
 - Enable development of initial requirements for each element
 - Determine ancillary implications of choices, such as effects on industrial base

SLS Analysis Approach



Approach:

- Leverage three government Requirement Analysis Cycle (RAC) Teams to create and study different design concepts that leverage capability across American industry
- In parallel, solicit industry input and concepts via study contract input

Implementation:

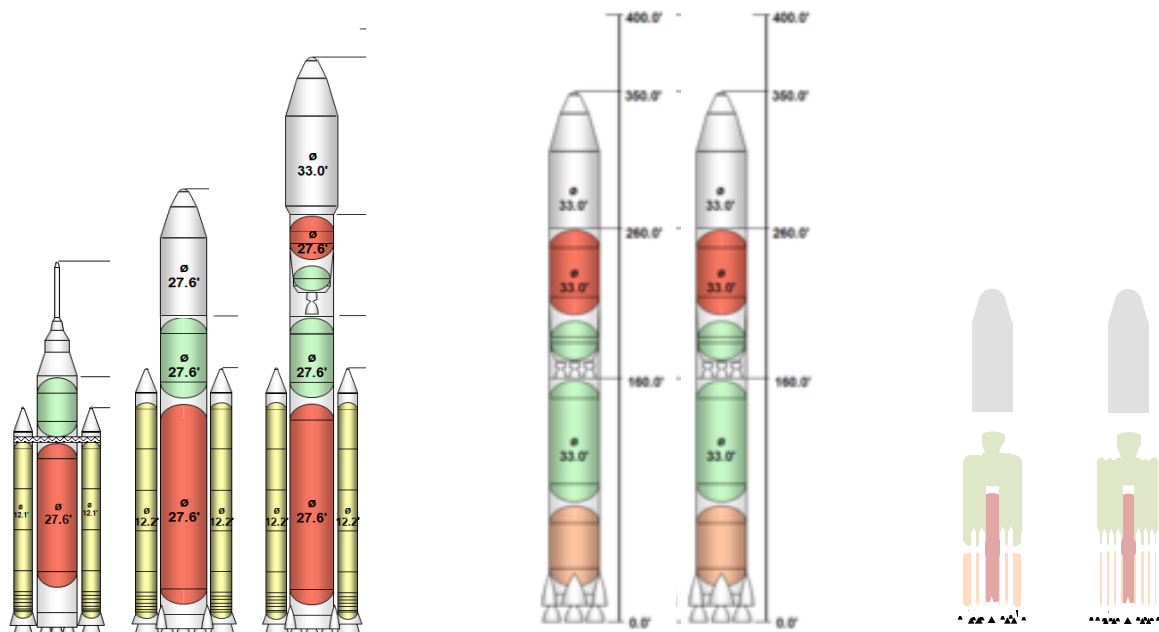
- HEFT and FOM studies (Fall 2010) concluded without architecture decisions
- Government Requirements Analysis Cycle (RAC) – Kick-off Nov 4
 - Three competing configurations with fourth team looking at cross-cutting affordability
 - Approaches to affordability addressed by all 3 teams
 - Common requirements (from HEFT), goals/threshold approach - tradable
 - Incorporate incremental inputs from NASA Heavy Lift study contracts
 - Out brief to SLS Feb 16-18
- Contractor Heavy Lift Study Contracts—awarded November 2010
 - 13 Contractors, \$650K each, 6 month studies – broad SOW ideas
 - Initial Out briefs Feb 22-24
 - Final Out briefs Apr 25-28

SLS Alternatives and Inputs from Industry



- **NASA is evaluating inputs from all 13 Heavy Lift Study Contractors**
 - In general, contractors' analyses favored their individual business models, however there are numerous innovative ideas
 - RAC Teams already incorporated several inputs into NASA studies: Requirements Stability to Minimize Cost, Commonality, Incentive-Based Acquisition, Risk-Based Insight/Oversight
 - Assessing: Lean Ground Operations, International Partnerships, In-space Refueling, Long-Term Program Stability Approaches
- **Only 3 contractors provided detailed cost and configuration data; these are being compared to NASA SLS RAC Study results**
 - Technical findings consistent with NASA RAC Teams
 - Provided data consistent with individual business models
 - Costs consistent for comparable content; in some cases complete system costs not provided (e.g. Ground Operations, engines, stages)
 - Comparing RAC to Study Contract Inputs
 - Inputs have been evaluated for applicability to SLS
 - This is the first step in an on-going and iterative process to evaluate cost basis of estimate and credibility
 - Will include RAC and applicable study contract submittals
 - Data will be used to support HEC independent cost assessment

Current SLS Concepts



	LOX/H ₂ – Reference Vehicle Design	LOX/RP	Modular
Description	Hydrogen core configuration with solid strap-on boosters; multiple evolution paths	Large RP configuration (large diameter tanks) with multiple engine options, incl. NASA/USAF common engine	Modular RP configuration (smaller diameter tanks) with multiple engine options, incl. NASA/USAF common engine
Lift Capability	70 mT – 150 mT	100 mT – 172 mT	70 mT – 130 mT

Note: Images based on government design solutions from RAC teams

Analysis of SLS Concepts Reveals Strengths and Weaknesses for Each Option



Team 1 - LOX/H₂

- Shuttle derived architecture consistently provides early, highly capable solution
 - Existing assets provides a fast, low cost start- flight test
 - Acquisition options provide a fast start
 - Only option that maintains US lead in technology and skill base for large Lox/H2 and large solid rockets
- The negative attributes of Shuttle-derived remain
 - High propulsion systems Production &Ops costs due to complex, reusable systems and infrastructure designed for higher launch rates than projected for SLS
 - Low incentive to change the proven but high cost approach
 - Block development approach to attain high end performance for future missions results in higher cost

Team 2 – LOX/RP

- Large RP consistently ranks as the most capable long term solution
 - High margins, simpler operations, and greater cost incentives due to competition and designing from clean sheet
 - High top-end performance easily attained for any future mission
 - Best LOC/LOM due to engine out capability
- The negative attributes of large RP remain
 - High peak development cost of new propulsion and delayed flight schedule
 - Requires unique (size-driven) infrastructure for new LOX/RP

Team 3 - Modular

- Modular architecture incorporates advantages and mitigates disadvantages of RAC Team 1 & 2 architectures to provide the lowest cost solution
 - Existing propulsion systems provides a fast, low cost start
 - Elimination of unique infrastructure lowers P&O costs
- The negative attributes of the modular architecture must be considered
 - Fast acquisition options probably not available
 - Limited performance and performance margin at the top-end
 - Lowest reliability
 - Core production limitations if manifest increases above 2 flights per year
 - Integration complexity (between elements and with ground)

MPCV Analysis Approach



- **The MPCV Analysis seeks to validate or challenge whether the beyond-LEO version of the Orion Crew Exploration Vehicle (the Reference Vehicle Design) is the most effective approach through:**
 - Understanding progress to date on the Orion development effort
 - Validating whether the Orion requirements closely match MPCV requirements consistent with the Authorization Act, which include utilizing the MPCV as the primary crew transportation vehicle for beyond-LEO exploration, as well as being capable to serve as backup for ISS crew and cargo transportation, although inefficient for that use.
 - Examining and implementing ways to increase efficiency and agility so as to be able to deliver an affordable and achievable crew vehicle as soon as possible. For example:
 - Streamlining government oversight and insight activities to ensure we are focusing on the key-risk items
 - Implementing an incremental approach to developing and building vehicle capabilities
 - Planning a more innovative and cost-effective vehicle qualification plan, utilizing distributed test labs, for example
 - NASA is also exploring other affordability measures including consolidating facilities and re-using test assets

Why Orion as Design Reference Vehicle



- **Analysis to look at a commercial LEO capsule and/or other design**
 - Exploration (beyond low Earth orbit) requirements are very different than those needed for a LEO trip (to and from ISS); not an easy comparison
- **Some differences:**
 - A deep space mission is longer in duration; the crew needs more habitable and cargo space.
 - A deep space mission requires approximately 5 times the propellant
 - The thermal protection system (heat shielding) needs to be much more robust as the capsule reenters at about twice the speed as compared to a LEO reentry
 - Farther distances from earth require us to have increased reliability of systems (not easy to abort)
 - More radiation shielding is required to protect our astronauts

Orion currently is designed to meet these
exploration class requirements



SLS/MPCV Integrated Analysis Process and Options

SLS/MPCV Integrated Analysis Process



- **Goal**
 - Explore the range of affordable, sustainable and credible alternatives for developing beyond LEO exploration capability by integrating various SLS and MPCV options
 - Ensure common understanding of drivers and features of each option through evaluating each alternative using common set of attributes
 - Work to optimize cost, performance and schedule to meet goals of Authorization Act
- **Alternatives consist of combinations of options studied by SLS and MPCV teams which explore the trade space in terms of technical and acquisition approach**
- **For each of the alternatives, analyze a set of discriminating attributes in areas of: Cost, Risk, Schedule, Performance, and Impact to NASA, industrial, national, and international capabilities**
- **Affordability Treated as a Gate, Not an Attribute**
 - Annual budget for integrated solution should not exceed available funding
 - Remainder of affordability factors tracked under cost attribute
- **ESMD/SOMD will use analysis of attributes for each integrated alternative to provide facts / data to NASA leadership for consideration**

Integrated SLS/MPCV Alternatives

Design Alternatives Currently Being Analyzed



Integrated Options

1: LOX/H2 with Strap On Boosters

Acquire as Elements

2: LOX/RP

Acquire as Vehicle/Element

3: Modular

Acquire as Vehicle/Element

4: Specify Performance (No Preferred Design)

Acquire as Vehicle/Element

5: Incremental Development

Leveraged test flight leading to competition

Beyond LEO Exploration Capability Attributes



CATEGORY	ATTRIBUTE		DESCRIPTION
COST	C1	DDT&E to Integrated BEO Capability	The total costs for DDT&E through the first flight of an integrated SLS/MPCV/GO stack for a notional BEO capability.
	C2	P&O per year for Integrated BEO Capability	The total costs for P&O of the integrated SLS/MPCV/GO stack for a notional BEO capability.
	C3	Date When \$300M Development Wedge is Available	The SLS/MPCV/GO stack, by itself, does not constitute a capability to conduct meaningful BEO exploration missions. Follow-on capabilities as defined by HEFT and future studies will need to be developed to conduct these missions.
RISK	R1	LOC	LOC risk for ascent, on-orbit operations, and re-entry of the combined SLS/MPCV/GO in a notional BEO configuration; includes performance margin.
	R2	LOM	LOM risk for ascent, on-orbit operations, and re-entry of the combined SLS/MPCV/GO in a notional BEO configuration; includes performance margin.
	R3	Cost Risk	Cost risk associated with DDTE and P&O through the notional BEO configuration.
	R4	Development and Operational Risk	Technical risk associated with DDT&E and P&O through the notional BEO configuration.
	R5	Flexibility Under Changing Budget Scenarios / De-scope Options	Budget stability is not assured through the DDT&E period. What are the options should there be cuts to the budget planned for SLS/MPCV/GO development? Is slipping schedule the only option? Or can content be de-scoped mid-way through the development cycle that would result in a less capable, but still useful, capability that could be built upon at a later time?

Beyond LEO Exploration Capability Attributes (con't)



CATEGORY	ATTRIBUTE		DESCRIPTION
SCHEDULE	S1	1 st integrated uncrewed test	First test of an MPCV integrated with an SLS.
	S2	1 st integrated crewed test	First test with a crew of an MPCV integrated with an SLS.
	S3	Integrated BEO capability	First flight of an MPCV integrated with an SLS in a notional BEO configuration.
	S4	Integrated Capability	Difference in months between SLS and MPCV completing DDT&E
PERFORMANCE	P1	Initial SLS payload capacity	Potential lift capacity of the first SLS test vehicle.
	P2	SLS evolutionary payload capacity	Planned lift capacity of the highest performance SLS block design.
	P3	Evolvability	Ability to increase performance capability without major redesign
IMPACTS TO NASA , INDUSTRIAL, NATIONAL, AND INTERNATIONAL CAPABILITIES	NINIC 1	Use of Competition	The extent to which acquisition strategy at the service, system, vehicle, or element level might impact number of competitors.
	NINIC 2	International Partners	Ability to leverage international partnerships in either the development or utilization of HEC capabilities.
	NINIC 3	DoD, Federal, and Commercial Partnerships	Ability to leverage partnerships with DoD, other federal agencies and industry in either the development or utilization of HEC capabilities.
	NINIC 4	National Space Industrial Base	Impact of the architecture to the national space industrial base and capabilities.
	NINIC 5	Civil Service Workforce Strategy	Any architecture will likely require significant changes to NASA's tradition civil service deployment strategy (including insight/oversight models) to meet affordability goals. All civil service analysis is dependent on acquisition strategy and make/buy decisions.
	NINIC 6	Use of NASA Facilities	High-level summary of how the SLS/MPCV/GO stack would utilize existing NASA facilities for DDT&E and P&O.

Summary and Next Steps



- **SLS/MPCV Integrated Analysis Process is underway**
- **Process leverages workforce from most NASA Centers and inputs from 13 Industry partners**
- **Results will guide NASA's approach to providing beyond LEO transportation capability for the Nation**
- **Results will form input to updated SLS/MPCV Report to Congress**
- **Interim results will be provided to NASA leadership and Congress over the coming weeks**
- **Schedule is challenging due to complexity of analysis, but NASA is committed to performing due diligence in our planning to ensure SLS and MPCV plans are affordable, sustainable, and credible**